Engineering Library

OCT 3 1923

No. 3. Vol. XVI. March, 1923.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

18/- Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/6 a Copy.

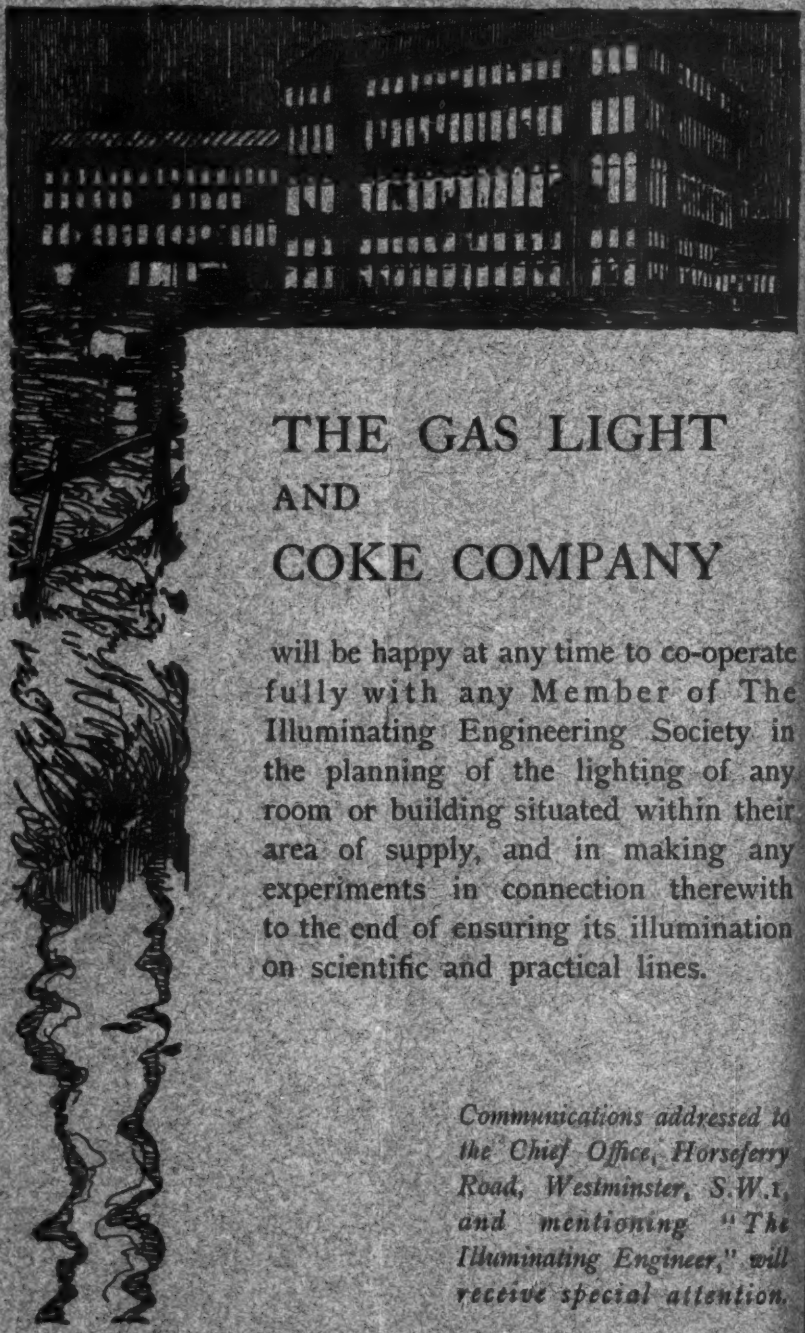
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
32, VICTORIA STREET, LONDON, S.W.1
(TEL. NO. VICTORIA 5215.)

This number contains an Account of the Discussion on **"The Projection of Light,"** which was opened by MR. W. J. JONES and MR. E. A. MARX, JR., at the Meeting of **The Illuminating Engineering Society** on February 20th, 1923.

Other matters dealt with include :—

THE LIGHTING OF POST OFFICES. THE LIGHTING OF SHOW WINDOWS. REVIEWS OF BOOKS, Etc.



THE GAS LIGHT AND COKE COMPANY

will be happy at any time to co-operate fully with any Member of The Illuminating Engineering Society in the planning of the lighting of any room or building situated within their area of supply, and in making any experiments in connection therewith to the end of ensuring its illumination on scientific and practical lines.

Communications addressed to the Chief Office, Horseferry Road, Westminster, S.W.1, and mentioning "The Illuminating Engineer," will receive special attention.

The ILLUMINATING ENGINEER

Edited by LEON GASTER

ELECTRICITY · ACETYLENE · OIL · GAS

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,

32, VICTORIA STREET, LONDON, S.W.1.

Tel. No. Victoria 5215.

EDITORIAL.

The Projection of Light.

Applications of light may be broadly divided into two classes, those in which the light is diffused and distributed over a wide area and those in which it is " projected," *i.e.*, confined by a lens or curved mirror within a limited beam. Most uses of light for ordinary purposes of illumination fall into the first class, while searchlights and motor-car headlights are extreme examples of projection.

In a searchlight, and even in the case of a headlight, the efficiency is fairly high though the percentage of light lost by absorption and obstruction is probably greater than in a well designed lighting installation. In the case of projectors used for " flood-lighting " and similar methods of local illumination the efficiency should also be fairly satisfactory. But there is one form of projection where the efficiency is at present notoriously low—when, as in the optical lantern and the kinema projector, we attempt to throw a picture on a screen.

Some experiences with the use of gasfilled electric lamps in optical lanterns are summarised in the paper read by Messrs. W. J. Jones and E. A. Marx, Jnr., before the Illuminating Engineering Society on February 20th are dealt with in the issue (see pages 62–72). Under the best

conditions the percentage of the original light reaching the screen did not exceed 5 to 10 per cent., though it is evident that there is much difference between various forms of lanterns in this respect. In the kinema projector it is generally agreed that the proportion of light reaching the screen is even less; and even this light is not all usefully employed since much of it is reflected on to the walls and ceiling of the theatre and does not reach the eyes of the audience.

Here, therefore, there is a field affording great scope for the efforts of the inventor. In many respects the arc-light is a very suitable source for projection purposes, as it furnishes a spot of light of high and uniform intrinsic brilliancy. But if an incandescent surface confined within a sealed glass envelope could be developed with similar light-giving qualities to the arc, it would be even more suitable for kinema work. Various special lamps, notably the "Pointolite" type developed in the Ediswan laboratory, have been devised for this purpose, the aim being to bring the source nearer to the condenser lens and thus utilise a greater percentage of the light. The experiments of Messrs. Jones and Marx in this direction are interesting, but it is evident that much remains to be done.

Other problems mentioned in the paper relate to the design of the kinema screen. One point that is now becoming appreciated is the desirability of avoiding an extreme contrast between the brightness of the screen and the surroundings. Dr. F. W. Edridge Green, in a recent paper before the Royal Society of Arts, agreed that such extreme contrasts are trying to the eye and do not enable the picture to be seen under the most comfortable conditions. In the future we expect to see the use of a moderate illumination throughout the theatre while the film is being shown become more general. Experience suggests that by a little care this can be provided without prejudice to the picture.

Many other instances of problems involving projection of light could be mentioned. The special inspection lamps for use in hospitals that were described before the Society a few months ago, and the optical devices used with reflecting galvanometers in physical laboratories, likewise offer opportunities for ingenuity and research. The introduction of flood-lighting for the illumination of the exteriors of buildings, monuments, etc., has made some progress and we have here a field where the co-operation of the architect is greatly needed. The use of methods involving some degree of projected light for illuminating advertisement placards has also become popular of late. Some examples to be seen in London are pleasing, others are somewhat marred by uneven effect. But it will be conceded that such methods of concealed lighting are greatly preferable to the traditional exposure of bright sources of light for purposes of advertisement.

We would like to draw attention to another example of projection—the projection of coloured light as illustrated by Major Adrian Klein's charming demonstration before the Society. This apparatus, which is in essence a giant spectroscope illuminated by a Beck searchlight, enables striking effects to be obtained when pure spectrum hues are projected on to coloured scenery, the whole picture being radically changed. Apart from the interesting features of the device as a medium for the projection of coloured light, the high intensity arc used is in itself an object worth study.

The Effect of Light on the "Drawing Power" of Shop-windows.

The value of good window-lighting is now appreciated much better than in the past and during recent years its influence in attracting custom has been fully recognised by leading stores in this country.

Some striking results of high illuminations in show-windows were recently described by Messrs. W. Sturrock and J. M. Shute in a paper before the American Illuminating Engineering Society. Experiments were made simultaneously in a number of stores in different parts of the country, the same method of lighting being used in each case, but the illumination adjusted to five levels, namely, 15, 40, 65, 85 and 100 foot-candles. Records were kept of the number of persons who stopped to look at the window in each case. There were fifty test-periods covering such widely different conditions as weather, the day of the week and other circumstances that might be expected to affect observations. The results from different parts of the country naturally varied somewhat, but all pointed to the same conclusion—that increased illumination has a material effect on the drawing power of the window. Generally speaking it appeared that an increase from 15 to 40 foot-candles increased the drawing power by 33 per cent., while with 100 foot-candles the drawing power was doubled.

In addition to high intensity the use of *colour* is helpful in attracting customers. It was found on the average that, for the same consumption of energy, the use of coloured light displays increased the drawing power by about 40 per cent. These results are striking. The cost of light forms but a small fraction of the overall running expenses of a large store. If, by using more light, the merchant can double the drawing power of his window, the expenditure would be well worth while.

The effect of brightly lighted windows in drawing custom has also been shown in a striking special experiment made in a store at the junction of two important streets. Two adjacent windows were equipped with identical methods of lighting, but with widely different intensities of illumination. It was then found that the number of people who entered the department with the brightly lighted window was considerably greater than in the case of the adjacently less well illuminated display, and that better business was done. To guard against the possibility that this was due to a difference in the nature of the goods, the contents of the two windows were interchanged and the experiment repeated. But the experience was still the same. Most people entered the section with the brighter lighting, and the best sales were effected in this case.

The influence of good lighting continues to be felt after customers have entered the store. Experience has shown that sales are effected more quickly as a result of improved lighting. This is doubtless partly due to the fact that both salesmen and customers can see the goods clearly. But, in addition, the mere fact that people are in a brightly lighted interior has a certain psychological influence, making them more inclined to come to quick decisions—an important point during special sales when it is necessary to deal with exceptional crowds of customers and to make the best use of the limited spaces available.

The Appreciation of Architecture.

We have often urged the need for closer co-operation between architects and illuminating engineers, and that fuller opportunities should be provided for them to become familiar with their respective points of view. In particular we have suggested that in courses on illumination a suitable explanation of the principles by which architects are guided in the design of buildings should be included.

Generally speaking, the layman does not get many opportunities of hearing a good exposition of these principles, and we therefore gladly take the opportunity of referring to the delightful address given by Professor Beresford Pite before the Scientific and Technical Circle of the Institute of Journalists on March 20th. Professor Pite traced the development of architecture from the past up to the present day, and gave many striking examples of the way in which the history of a country is engraved in stone, the architect faithfully expressing the spirit of the age. For this reason, he suggested, it is futile to sigh for " the glory that was Greece and the grandeur that was Rome," for a building suited to the free communities of the present day must differ from those designed to express the dominating influence of Empires of the past. A similar question often arises in connection with lighting fittings, and we think that it might reasonably be suggested that in a modern building it is best to aim at designs adapted to the present age of gas and electricity, rather than to seek to perpetuate types which, however graceful and charming in appearance, were primarily devised to support oil lamps or candles and cannot readily be adapted to modern illuminants.

Professor Pite contended that a mere verbal description cannot convey all the impression created by a fine building, that there is an elevating and mysterious influence which can be felt but cannot easily be reproduced in writing. Journalists should bear this in mind. But it is most useful for members of the Press to have such an opportunity of gaining some insight into the complex circumstances determining the trend of architecture and the aims and aspirations of the architect. We agree that the Press can exercise a very useful influence in encouraging public appreciation of good architecture and counteracting the unduly materialistic spirit that is apt to govern the erection of new buildings.

In the course of the discussion Mr. Herbert Wills gave a very happy definition of the artist as one who found a joy in his work, a definition that was entirely endorsed by the lecturer, and pointed out that the humblest worker could be an artist in this sense. It has sometimes been suggested that illuminating engineers are too prone to dwell on " efficiency " in the narrow sense and are not sufficiently open to artistic conceptions. In order to counteract any such tendency it is essential that they should have opportunities of becoming familiar with the ideas of artists and architects on lighting matters, and if, in addition, they do their work with enthusiasm and conscientious effort, their co-operation should be welcomed as artists in the sense of the definition quoted above.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE PROJECTION OF LIGHT.

(Proceedings at a meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, February 20th, 1923.)

A MEETING of the Society took place at the House of the Royal Society of Arts (18, John Street, Adelphi, W.C.), at 8 p.m., on Tuesday, February 20th, 1923, the chair being taken by Mr. HAYDN T. HARRISON.

The Minutes of the last meeting were taken as read, and the HON. SECRETARY read out the names of the following new applicants for membership :—

Ordinary Members :—

H. F. BUCKLEY	Section of Photometry; National Physical Laboratory, Teddington.
J. P. CONELLY	Electrical Engineer, P.W.D., Simla, India.
H. A. EASTER	Director of the British Electrical Co., 25-29, Tower Street, Rotherhithe, E.C.
R. C. HALL	London Representative of the Engineering and Lighting Equipment Co., Ltd., 89, Parchmore Road, Thornton Heath.
C. W. SULLEY	Director of the Electric Lamp Manufacturers' Association of Gt. Britain, Ltd., 25, Bedford Square, London.
J. W. T. WALSH	National Physical Laboratory, Teddington.
H. H. LONG	Tech. Assistant, Holophane, Ltd., Elverton Street, Westminster S.W.1.

Associate Member :—

L. W. DUNN	Student in Electrical Engineering, 19A, Theatre Street, Clapham Junction.

The names of applicants read at the last meeting, on January 16th, were announced again and these gentlemen were formally declared members of the Society.

The CHAIRMAN then called upon Mr. W. J. JONES to read the paper by himself and Mr. E. A. MARX, Jr., on **"The Projection of Light,"** and an interesting discussion ensued, in which Commander BAKER, Dr. R. S. CLAY, Major A. KLEIN, Mr. J. ECK, Mr. T. E. RITCHIE, Mr. L. E. BUCKELL, Mr. W. E. TRUSLER, Mr. P. J. WALDRAM, Mr. J. S. DOW and the CHAIRMAN took part.

Features of special interest were the demonstration of his colour-projector by Major KLEIN and the exhibit of a three-phase projector arc by Mr. J. ECK.

After a vote of thanks had been passed to the lecturers and exhibitors, the Chairman announced that the next meeting would be held on March 27th, when a discussion on **"Window Design and the Measurement of Daylight Illumination"** would be opened by Messrs. P. J. and J. M. WALDRAM.

THE PROJECTION OF LIGHT.

By W. J. JONES and E. A. MARX, JR.

(Introduction to a Discussion at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, February 20th, 1923.)

INTRODUCTION—HISTORICAL NOTES.

Roger Bacon, one of the earliest men in Europe to turn his attention to science after the fall of Rome, is said to have invented the "Magic Lantern." He certainly had a knowledge of optics far in advance of his contemporaries, but there is no definite evidence in any of his works to show that he was the inventor.

The first actual information about the projection of light is some three centuries later when Giambattista della Porta (1538-1615) either invented or improved the lantern. Then again, in 1646, Athanasius Kircher described it in his book "Ars Magna Lucis et Umbrae." Since then the lantern itself has not altered much, though there have been considerable changes in the light source employed.

The earliest illuminants were probably oil lamps burning vegetable and animal fat, but these were very inefficient until the introduction by Argand, towards the end of the 18th Century, of circular wicks and of the glass chimney.

Then early in the 19th century the introduction of gas lighting provided a much better source of light. It was used in several ways, with several burners in a row along the axis of the lantern or, when later the gas mantle was introduced, a single burner with a concave spherical mirror behind.

During the last century, too, several other methods were introduced, the best of which were acetylene and limelight, both of which are still used quite extensively where electricity is not available.

But more important by far was the development of the electric arc; this was actually invented by Sir Humphry Davy quite early in the century, but it was not made of practical application until many years later. At the present day it is easily the most widely used light source for projection work.

Of recent years, however, still another source has been developed. Shortly after the gasfilled lamp came into general use, experiments were begun, chiefly in the U.S.A., with a view to using a similar lamp for cinematograph projection work, and after a short time quite good results were obtained.

COMPARISONS OF PRESENT SOURCES OF LIGHT.

(1) *The Electric Arc* has a high intrinsic brilliancy, it develops a very high flux value of light giving as much as 6,000 H.C.P. It is practically a point source of light. On the other hand the light is fluctuating and the arc requires frequent attention and considerable power is necessary. Moreover, the efficiency is impaired since only about fifty or sixty volts are absorbed in the arc itself, which implies the use of expensive electric machinery and, in the case of A.C. supply, a converter, since the light flickers badly and a humming noise is produced if A.C. is used. In addition to this there is an enormous amount of heat involved and the initial cost is considerable.

(2) *The Gasfilled Lamp* has a high intrinsic brilliancy and produces a high flux value giving upwards of 3,000 H.C.P. It only approximates to a point source in low voltage lamps when the filament can be coiled into a sufficiently small space. The light, however, is steady either on A.C. for D.C. supply, but it is not yet much used in this country for very high power work. The prime cost is quite low and it is easy to operate.

(3) *The Pointolite* gives a good intrinsic brilliancy and a good flux value. The H.C.P. is as high as 1,000. It is a point source and it gives a good steady light on D.C. It is not, however, so easily operated on A.C.

(4) *The Nernst Lamp* gives a high intrinsic brilliancy and a high flux value

giving as much as 800 H.C.P. It is approximately a point source and gives a steady light but is very complex and hence more liable to fail. It is expensive and extremely fragile and is not available for powerful projection.

EXPERIMENTAL WORK.

Experiments were carried out for three objects:—

(1) To determine the amount of the losses due to the lens system.

(2) To estimate the percentage of the total light produced that was usefully employed on the screen.

(3) To compare the results obtained from a 4-amp. arc with those obtained from 400-watt gasfilled lamps of different voltages.

Two lanterns were used and in each case the illumination on various parts of the screen was taken by means of a Holophane Lumeter, and from that the total lumens calculated first with the lens and slide carrier in exactly as the lantern is in use; then with the slide carrier out; then with the lens out as well, and then with the mirror behind the lamp removed and the lens in.

The following results were obtained:—

DESCRIPTION OF LANTERNS.

I. *Unknown make.*—Lens 8½ in. focus, 2⅜ in. dia. Condenser combination concave-convex 4¼ in. dia.

II. *W. Watson Lantern.*—Lens 8½ in. focus, 1⅝ in. dia. Condenser combination plano convex, 4 in. dia.

The results tabulated are all that could be easily obtained and many tests were abandoned because of the impossibility of calculating the amount of light falling on the screen, with a reasonable degree of accuracy.

A consideration of the results obtained with a 400-watt Gasfilled Lamp of 4,750 lumens shows that the resultant illumination on the screen for similar size lanterns may be from 3 to 4·9 per cent. of the light produced. The second lantern shows great superiority.

It is also interesting to note that the mirror behind the lamp increases the illumination so that an increase of nearly 50 per cent. light flux is recorded. The mirror used was not of a high degree of accuracy but apparently served its purposes well.

It was adjusted in position so that when the direct image of the filament appeared on the screen, the image obtained by reflection was superimposed.

Since the flux values of the lamps were known and the optical systems gradually built up, it is possible to obtain some approximate figures concerning the losses. Perhaps the most striking feature of all lies in the fact that of the total flux of the light source not more than 6 per cent. is usefully employed and reaches the screen. We are tempted to ask what becomes of the rest and whether the optical instrument maker cannot offer some suggestions to improve this. It will be seen that 80-90 per cent. of the light is lost between the light source and the slide, even when a mirror is used, and a further 6-14 per cent. is lost between the slide and the screen. Without doubt some of this is accounted for by the absorption of the condenser and the lenses, and still is more due to the fact that the slide is square and the lenses circular.

The discussion of the improvement of the optical system is beyond the scope of this paper, but reference might well be made to an article by F. H. Richardson on "Some phases of the optical system of the projector" and by H. P. Gage on "Condenser design" (Trans. Society Motion Picture Eng. 1919). Some systematic work has also been done in this country, notably by Mr. A. C. W. Aldis.

In the course of the experiments it was noted that a great deal of reflection occurred from the back of the condenser and lens. An endeavour to measure its amount was unsuccessful.

For the experimental work gasfilled lamps of different voltage and the same wattage were used. It is general experience that low voltage lamps give more satisfaction than those of high voltage and this was amply borne out in the data obtained. In the first place the low voltage lamps are the more robust for they have thicker filaments and are therefore capable of withstanding

much greater mechanical shock. Moreover, since a low voltage lamp has less effective surface for the convection of heat by the gas present in the bulb, it loses less heat in that way, and the filament can be operated slightly more efficiently. account of its small area of filament it permits the optical system to operate more efficiently. It will be seen that the low voltage 400 watt lamps give 32 per cent. better result than the high voltage lamp. The extra light flux available for

TEST FIGURES.

—	Lantern I.—Unknown.			Lantern II.—W. Watson.			
	Lumens.	% light.	% loss.	Lumens.	% light.	% loss.	
Lamp	4,750	—	—	4,750	—	—	
Condenser in, lens and slide carrier removed	593	12·5	87·5	—	—	—	
Condenser in, useful light only ..	425	9	91	—	—	—	210 v. 400 w. Lamp.
Condenser and lens in, slide carrier removed	168	3·5	96·5	260	5·5	94·5	
Condenser, lens and slide carrier in	142	3	97	234	4·9	95·1	
Condenser and lens in, mirror and slide carrier removed ..	111	2·3	97·7	181	3·8	96·2	
Lamp	—	—	—	5,430	—	—	
Condenser in, lens and slide carrier removed	—	—	—	1,183	21·8	78·2	
Condenser in, useful light only ..	—	—	—	910	16·75	83·25	
Condenser and lens in, slide carrier removed	—	—	—	362	6·65	93·35	95 v. 400 w. Lamp.
Condenser lens and slide carrier in	—	—	—	294	5·4	94·6	
Condenser lens in, mirror and slide carrier removed ..	—	—	—	301	5·55	94·45	
Lamp	—	—	—	2,640	—	—	
Condenser in, lens and slide carrier removed	—	—	—	548	20·7	79·3	
Condenser in, useful light only ..	—	—	—	532	20·2	79·8	105 v. 250 w. Lamp.
Condenser and lens in, slide carrier removed	—	—	—	159	6	94	
Condenser, lens and slide carrier in	—	—	—	112	4·25	95·75	
Condenser, lens in, mirror and slide carrier removed ..	—	—	—	129	—	95·1	
Condenser and lens in, slide carrier removed	196	—	—	330	—	—	Arc.

In each case a lantern slide was carefully focused and the position of lamp adjusted to give as even illumination as possible.

Data Respecting Lamps.

400-watt Gasfilled lamp =	2 amps. 210 volts	gross area of source	0·9″×0·56″=0·544″
400-watt „ „ =	4·1 amps. 95 volts	„ „ „	0·55″×0·56″=0·275″
250-watt „ „ =	2·3 amps. 105 volts	„ „ „	0·55″×0·56″=0·275″

The result is that a low voltage lamp (100-130 volts) is capable of giving approximately 15 per cent. more light than a high voltage one (200-260 volts) of the same wattage. Furthermore, on the reason mentioned above accounts for 15 per cent. of this, the remaining 17 per cent. apparently being due to the smaller source of light.

As a further proof of this a 400 watt

L.V. lamp was exchanged for a 1,000 watt H.V. lamp with very little difference in the resulting illumination. Excellent results are obtained with still smaller sources of light.

Perhaps the chief difficulty in the manufacture of gasfilled lamps with concentrated filaments for normal voltages lies in the fact that the filament has to be well spaced in order to prevent thermionic arcing.

One of the chief objects of the experiments was to compare the effectiveness of the gasfilled lamp and the arc for lantern work in Schools and small Lecture Halls. The comparison was made with the best of the small arcs.

From the above considerations it will be apparent that the gasfilled lamp works best when operating on a low voltage supply whereas the arc only works satisfactorily when on a D.C. supply.

The tests were taken on 210 volts D.C., the current consumption being—Arc 4 amps., gasfilled lamp 2 amps., approximately. Also the two lanterns were tested and the lamps adjusted to give an 8 ft. picture with approximately 20 ft. throw.

By means of a lumeter the distribution of light on the screen was measured at many points. These results were plotted and contours drawn.

The following are the maximum and minimum values of the illumination then :—

LANTERN No. 1.

	Arc.	Gasfilled lamps.
Max. illumination at centre	4·3	5·0
Min. illumination at corners	3·0	1·0

LANTERN No. 2 (WATSON'S).

	Arc.	Gasfilled lamps.
Max. illumination at centre	5·4	5·2
Min. illumination at corners	2·0	3·0

As would be expected, there is a difference of the colour value of the light on the screen, but apparently there was little to choose as regards visibility. If anything, the gasfilled lamp appeared to show more detail. In the case of Lantern No. 1 with the gasfilled lamp there was a lack ot definition in the corners but with the other lantern it was in every way satisfactory both as regards definition and evenness of illumination. This is apparent from the contours (2 slides).

There is the same curious distribution both with the arc and the gasfilled lamp although the light source in the two cases is vastly different as regards shape and dimensions.

Manufacturers of gasfilled lamps are doing all they possibly can to introduce more powerful lamps and one looks forward to the day when the arc and its attendant difficulties will be entirely supplanted by projectors of the gasfilled type.

CINEMATOGRAPH.

Cinema projection presents several quite special problems which deserve brief consideration here though the subject is much too big to be treated in detail.

Firstly, about 50 per cent. of the light is cut off by the revolving shutter. It is usually arranged so that the periods of light and darkness are about equal. Sixteen pictures are shown every second, so that the shutter cuts off the light 16 times a second. This, however, is modified, for in most types the shutter is not quite opaque, but has a number of little holes all over it so that some light can pass through and the screen is never in absolute darkness. Also it has sometimes been found advisable to break up the shutter so that the same picture is shown perhaps twice, that is, the light is cut off 32 times a second. This is said to reduce the effect of flicker. At any rate, however the shutter is made, it is clear that there must be much more light required for cinema work than for similar slide work on account of that alone.

Also the object to be projected is much smaller. The film picture covers about one-twelfth the area covered by a slide and consequently the light has to be brought to a much smaller area. This is done by using a similar size condenser, about 4½ inches diameter, and placing it further away from the film, say about

7 or 8 inches, and then the objective lens is arranged so that it is quite close to the film. By this means a similar amount of light is used from the same source both for slides and films.

The atmosphere in Cinemas very often becomes smoky and sometimes the throw from the operating room to the screen is as much as 160 feet, so that some absorption of light must be allowed for. This, however, is not great.

There is really not much difference in the percentage of light transmitted by a slide and a film respectively. Several of each were compared and in some cases the film was better and in some cases the slide, so that there is not much difference on that matter. But it will be noted that the proportion of light usefully employed on the screen is even smaller than in the case of the optical lantern.

In addition to these considerations there are many mechanical difficulties, a discussion of which would be out of place here.

The following examples may be of interest. At a certain Cinema in North London, which is operated on a throw of 160 feet, Sunlight arcs are used working on 90 amperes. The resultant illumination on the screen with the shutter not moving and no film in, is 12 foot-candles fairly uniformly. The size of the screen is 25 feet by 18 feet so that this represents about 5,400 lumens on the screen. When, however, the machine is in operation, the brightest parts of a film, such as the sky, have a foot-candle intensity of only about 1 foot-candle. This is practically the same when viewed from all parts of the house.

In the case of a small house machine with a throw of 15 feet, using a 100 volt 400 watt gasfilled lamp, 13 foot-candles were produced with no film in, and the shutter stopped.

SCREENS.

The reflectivity on a screen is really not a true measure of its value because, of the total light reflected by it, only about one-fifth is useful. The rest is wasted on the walls and ceilings. Now some materials disperse the light much more than others in reflection so that it is best to choose a screen which reflects the light in the most useful manner; that is to say, does not diffuse it too much, but at the same time does not produce glare. Screens of semi-polished material have been devised and by this means a considerably brighter image, as seen by those immediately in front of the screen, may be produced. But naturally this is at the expense of the brightness as observed at oblique angles, and therefore such screens must be used with discretion in halls of considerable width. Optically the method of projecting the picture on to a translucent screen from behind has some advantages, but clearly requires a considerable addition to the length of the hall. It would be interesting to hear some experience of this method.

An important point in considering the screen is the loss of definition due to external light. Suppose, for example, the bright part of a picture on the screen has an illumination of 1 foot-candle and the dark part ·05 foot-candle. The ratio of these values is 20. Now suppose an extra ·05 foot-candle due to the general lighting of the theatre is imposed on this, the values become 1·05 and 0·1 and the ratio is now 10·5. That is to say the definition has been reduced to one half, and hence it is important that the screen should be shielded as much as possible from any external illumination.

On the other hand it has been contended that absolutely dark surroundings are not desirable, as the contrast with the brightly illuminated screen is trying to the eyes, and a subdued general illumination enables pictures to be seen with greater comfort. It is therefore desirable to aim at producing subdued illumination of surroundings, in such a way that as little as possible of this diffused light strikes the screen. A method of grading the illumination, from 0·2 foot-candle at the back of the theatre to zero near the screen, used in an American cinema hall with success, has been described.* It may be recalled that Joint Committees of the Society on "Eyestrain in Cinemas" found that the requirements, that the illumination in all parts of the theatre should not be less than one-fortieth foot-candle, could be

* See ILLUM. ENG., Oct. 1919, p. 290.

readily satisfied without prejudice to the picture, and that by using suitable methods of distributing the light, this illumination might be somewhat increased.

Very often in the U.S.A. the screen is coloured yellow. The reason for this is that the eye is more sensitive to yellow light than to any other and also the general illumination of the Theatre is certain to be rather yellow seeing that it is lighted by artificial light so that it is rather a contrast to look at the comparatively white light from the arc after seeing only the yellow. This practice does not seem to have found much favour in this country.

OTHER PROJECTION PROBLEMS.

It would be possible to mention many other problems involving the projection of light. While this paper has been confined mainly to the optical lantern and cinema projector, no doubt there will be opportunities in the discussion of considering questions that arise in connection with such applications as motor-headlights, searchlights and floodlighting. Searchlights and motor-car headlights have been fully discussed at several discussions before the Society in past years. Some of the interesting optical problems that arise in connection with aerial lighthouses were also treated in the paper by Lt.-Col. Blandy on "The Use of Light in Aerial Navigation" last year.

The term "floodlighting" is now widely used to describe methods of illuminating large areas by concealed sources, equipped with suitable reflectors. Illuminated advertisement placards are now becoming very usual in London and several instances of the use of floodlighting to illuminate the exteriors of buildings have been mentioned in THE ILLUMINATING ENGINEER from time to time. Not infrequently successful lighting of this kind needs careful design of the reflector and judicious spacing of the sources to obtain even illumination with the lights relatively close to the area illuminated. The control of the light in this case is effected by the aid of reflectors, and in some cases the beam is confined within a small angle of dispersion, so that the arrangement has a good deal in common with a searchlight of moderate power. In this case, as in the optical lantern and cinema projector, the use of a filament concentrated within a small area, so as to approximate to a "point-source," is of importance.

Another field of lighting where projection of light plays an important part is the stage. Various special forms of lighting units for producing strong local "spot-lighting" have been devised, and possibly some reference to these may also be made in the discussion.

In conclusion it must be stated that this is in no way an exhaustive examination of every aspect of the subject, but is rather intended to provide a basis for discussion, and to set forth what is known about the subject and so make more clear the difficulties that are to be contended with, and in what directions improvement is called for most urgently. The writers also desire to thank Messrs. Siemens & English Electric Lamp Co. for kindly allowing the experiments to be made.

DISCUSSION.

Major ADRIAN KLEIN, who opened the discussion, gave a striking demonstration with a model of his new colour-projector. The instrument is essentially a gigantic spectroscope of the auto-collimating type, with a set of electrically controlled shutters, each shutter coming opposite a predetermined portion of the spectrum. An arc of entirely new design provides the beam, which is broken up into its elements by a large sectional prism. There is a separate source of white light, with which the colours can be diluted to any extent, and the intensity of the beam can also be regulated by means of two adjustable diaphragms.

The first application of the apparatus is for the production of stage effects. Major Klein showed how, by altering the colour of the light falling upon pictures, their appearance could be entirely altered, as certain tints appeared bright

while others were suppressed. This idea has been applied on the stage to produce remarkable changes of scene.

The apparatus is provided with a keyboard to facilitate the development of "colour-music," combinations and sequences of colours being evolved to produce effects which are pleasing to the eye in the same manner as audible music is agreeable to the ear.

Major Klein also mentioned some of the special features of the Beck arc used with this apparatus. The arc utilises electrodes with cores heavily impregnated with salts giving a highly luminous flame. Pure carbon can be raised to a temperature of about 3,800° abs. under ordinary conditions, and no increase in current will raise the temperature appreciably above this value. But the core-gas of the high intensity arc is not hampered by this limit and there is evidence that it reaches a temperature of at least 5,500°, comparable with that of the sun. Photometric measurements have shown that the centre of the gas crater is over five times as bright as the crater of the ordinary carbon arc.

Mr. JUSTUS ECK exhibited a new form of arc, having three converging carbons, suitable for use on a three-phase supply. This apparatus had proved quite satisfactory and eliminated the expense of installing motor generators. He also showed in operation a small form of projector that had several novel features, including a positive horizontal carbon and a vertical negative one, which arrangement eliminated the obstruction from the negative carbon.

Referring to the paper, Mr. Eck said that the polar curve of light distribution furnished by the gasfilled lamps used by the authors was far from ideal, as much of the light was emitted in directions that could never reach the condenser.

Mr. Eck then demonstrated on the board the polar curve of the lamp that he had previously exhibited. Continuing, he said that he would like to emphasise what had been said already on the importance of getting correct carbons for arc lamps. He had found variations as great as 50 per cent. in the light emitted from the same lamp with the same current through a projection apparatus.

The author asked for information on the projection of objects with a translucent screen. There was a great deal to be said in favour of this method. All who had sat in a cinema had seen the diffusion of light from the smoke, and the luminous haze thus created was very troublesome as it produced a sort of glare. The drawback of scattered light from smoke could be avoided and the advantages of subdued general lighting of the room secured by using a translucent screen.

It was sometimes assumed that the increased length of the hall was an insuperable difficulty. But this was due to the poor knowledge of optics possessed by people who erected cinema houses. He had been in a theatre at Glasgow where they projected the pictures on a translucent screen, but the space behind the screen was exactly as long as that in front of it; whereas if they had used a wide angled lens a good deal of this space could have been saved. Further than that, they boxed the space from the projector to the screen in an enormous square truncated cone, a quite unnecessary expense. Quite recently he had been on a screen committee with another gentleman, who had held the view that the only thing was to project *on* the screen, whilst he (the speaker) held the view, with the strong backing up of Mr. Ritchie, of projecting *through* the screen. He and Mr. Ritchie had carried their point, and in so doing had achieved something they did not expect; for although they got about the same intensity of light on the screen, they also got a considerable amount of diffused light throughout the room, rendering observation better and making the conditions much more agreeable.

Commander T. Y. BAKER was invited to open the discussion, but stated that he could not offer any adequate technical comment upon the intensely interesting paper that they had heard from Mr. Jones, nor on the very beautiful demonstration that had been given them of the spectral projection of colour by Major Klein. He would therefore confine himself to an expression of thanks on the part of the Optical Society, of which he was a member, for the Illuminating Engineering Society's exceedingly kind

invitation to attend this meeting and take part in the discussion and listen to the very valuable papers that had been given.

Dr. R. S. CLAY said that he had listened with very great interest to this paper. One of the greatest difficulties in obtaining good illumination in projection was caused by the large spherical aberrations present in nearly every condenser that he had examined. As a rule the cones of rays from a point source passing through the various zones of the condenser were focused at different distances, with the result that unless the projecting lens had a very large aperture a great proportion of the light was lost. It was also usually forgotten that the condenser was forming an image of the source of light in the neighbourhood of the projecting lens, and that that image was magnified according to the ordinary rules for the formation of images by a lens; thus if the condenser were a perfect one and free from spherical aberration, the image of the source of light so formed was as many times greater than the source itself, as the distance of that image from the front principal plane of the condenser was greater than the distance of the source behind the back principal plane of the condenser. In the case of a cinematograph this magnification would be six or eight to one—thus the image of an arc crater $\frac{1}{4}$ in. in diameter formed by a perfect condenser would be at least $1\frac{1}{2}$ in. in diameter. This magnification would be still further increased if the source were brought up closer to the condenser and the image correspondingly shifted forward; so that the gain of light which might be expected from the inclusion of a larger cone of light by the condenser would be lost, unless the projecting lens also had a correspondingly larger aperture. In cinematograph projection he believed that the best illumination was usually obtained by focusing the crater on the film, since the image of the crater was usually large enough to cover the whole area of the picture, and the illumination with a good condenser was sufficiently even to be agreeable.

The magnification of the source by the condenser, above referred to, must make the gasfilled lamp (of which the area of the filament was usually at least $1\frac{1}{2}$ in. diameter) an unsuitable one for cinematograph projection, since this projected image would, even with a perfect condenser, cover an area 3 ins. or 4 ins. in diameter. Even with the ordinary lantern, a large projecting-lens and a short front cone were desirable if the best results were to be obtained from a gasfilled lamp.

Mr. T. E. RITCHIE said that he would like to congratulate the authors of the paper upon the care with which they had undertaken this investigation. He thought that their experience of arcs must have been either very limited or very unfortunate, for he could not imagine anyone deliberately choosing an enclosed arc for projection purposes where the actinic value of the rays was not of importance. There were now available arcs of the self-feeding type, which were entirely automatic in their action and quite free from trouble, and which were capable of running for an hour or upwards at a time, without being touched, on currents of from two to six amperes.

He quite agreed with Dr. Clay that it was almost impossible to expect from any commercial condenser the results which as projectionists they would all like to gain. It appeared, however, from the contours shown upon the screen, that the condensers that the authors had used had been particularly unsuitable.

The authors had enlarged upon the trouble experienced with arc lamps. He thought it only fair to those engaged in the production of such to point out that one could have the most perfect arc lamp, the most trouble-free device that could be thought of, but unless it was trimmed with proper and suitable carbons endless trouble would be experienced with the lamp. But if this point was attended to there should not be any trouble. Moreover, he might say, from the point of view of simplicity and ease of attention, that self-feeding arcs were in use in a number of schools and educational establishments, where, although those responsible for their operation were not by any means expert projectionists, they were able to obtain

satisfactory and efficient results without any trouble or difficulty.

Mr. L. E. BUCKELL said he did not wish to waste time thanking the authors of the paper, but they ought to be thanked because the subject they had brought up was one becoming of very great importance indeed. Several of the speakers had discussed various aspects of the subject, but the one that interested him most was the use of gasfilled lamps for projection purposes. There had not been much said that evening as to the obvious advantages of the use of gasfilled lamps for projection work or their disadvantages, if any; might he be permitted to raise one or two points that seemed to need investigation to ensure the use of these lamps to the best advantage.

Dr. Clay had pointed out that with a source of light of larger area, one must necessarily get a larger resulting luminous area pictured by the condenser and must therefore use a larger projection lens. That was a point with which lens and lantern manufacturers must deal. If gasfilled lamps were to be used to entirely replace arc lamps for projection there must be optical apparatus designed on somewhat different lines from those existing at present. The present design was capable of considerable alterations, and when this had been done it would not be only the four per cent. or six per cent. of the light that the writers of the paper had referred to which would be obtained from the screen.

Another point was surely that the inefficiency of the use of light was largely due to the fact that they were using the condenser with an 8-in. focus. The amount of light that fell on the condenser was obviously the maximum amount of light that could be projected on the screen. The further the distance of the condenser from the light source the smaller the solid angle of light that you got on the condenser, and, therefore, the smaller total proportion you were using. One would think that the lantern used by the authors of the paper must have been an unsuitable one for the use of gasfilled lamps. The arc lamp was necessarily kept some distance away from the condenser, for if not, your condenser costing perhaps from £4 to £6 might crack, but with a gasfilled lamp that did not hold, because you had not got the same concentration of heat at a point, and so you could bring the gasfilled lamp much nearer the condenser, especially if designed with a tubular bulb and a filament near the edge of the bulb. He would ask lantern designers to help illuminating engineers by bringing in designs with shorter foci than had been the case with arc lamps, because this would enable a bigger percentage of the light from the gasfilled lamp to be used.

The chief disadvantage in connection with the use of arc lamps that had been mentioned in the discussion, was that care was necessary in their use. Yet a projecting apparatus had to be used by all sorts of people, especially in stage use. Semi-skilled and almost unskilled people were not going to take the trouble to get all the various details right, and in this respect the gasfilled lamp had advantages. The relative advantages of a projector lamp which could be used on a high voltage circuit with its drawbacks, or the more perfect low volt projector lamp which could be used with local circuit and resistances, was a subject which would require an evening to discuss.

Mr. P. J. WALDRAM referred to the American practice of colouring the screen yellow because yellow was more sensitive to light. Surely, he said, it was not a question only of the light that was projected on the screen, it was the amount that came off the screen that we saw; and it would appear, therefore, that introducing a yellow tinge into the screen was directly reducing the amount of light, even though the eye might be more sensitive to it.

Mr. W. E. TRUSLER said that as one associated with the licensing authority for London he would like to raise one or two points. He noticed that none of the speakers had referred to the heat developed by the projection gasfilled lamp, which might constitute an objection to its use on the stage and elsewhere. He would also like to inquire whether any tests had been made as to the effect of an

ordinary normal fog in the room ? What was the increase of current necessary, if any ?

Mr. J. S. Dow expressed his appreciation of the delightful demonstration by Major Klein; the effects produced by using spectrum colours were exceptionally striking.

It was of interest to observe that the new form of searchlight with cooled electrodes was being used for cinema work. The angle of inclination between the carbons had to be selected with some care, according to the use to which the arc was put; in the case of searchlights it was different from that employed in the cinema-projector. It was sometimes assumed that the brightness of the screen was not greatly affected, within limits, by the current passing through the arc. But in the case of this form of arc the variation, according to some American results, appeared to be very considerable.

The very low efficiency of the cinema-projector, to which the authors had referred, suggested that there was great scope for inventors in this field. Gas-filled lamps with concentrated filaments had been used in the United States. The aim was to bring the filament near the condenser, which was of a special semaphore type, so that the flux of light embraced by it was as great as possible. Many years ago he had the idea of replacing the condenser by an elliptical mirror, the source being placed at one focus and the objective at the other; but in practice the idea had proved quite impracticable. For one thing, if the light source departed appreciably from a "point source," the proportion of light arriving at the second focus was extremely small.

The CHAIRMAN (Commander Haydn T. Harrison) said that before calling upon the authors to reply he would like to say a few words on the subject, as much of his time had been given up to research in this direction. He was very pleased to be able to tell Major Klein that during the War the British Navy had made use of a very large number of lamps constructed on the Beck principle. It had been his (the Chairman's) duty to devise means by which this principle could be put into practical use, with the result that the lamp known as the "Harrison Lamp" had been developed and used throughout the Grand Fleet and Cruiser Squadrons. The United States had developed the Sperry Lamp, which was similar in many ways, but did not use a hydro carbon flame to prevent the shell of the positive carbon from being developed too quickly.

The principles described under the heading of the Beck Lamp in the American and German papers were not novel; they included the use of a positive carbon containing a core embodying cerium fluoride, and the rotation of same in a flame of hydro carbon gas, but the work of embodying these into an automatic lamp suitable for sea service had not proved any too easy.

The high efficiency obtained by this construction had led to many different theories as to the cause, but he was not of opinion that it was due to increased temperature of crater, but was more a question of the electron conditions and the selective radiation characteristics. In fact, an analogy was found in the gas mantle, in which the introduction of a very small quantity of ceria made such a marked difference to the efficiency.

He did not know why Mr. Jones had used the term horizontal candlepower, later on he had got back to lumens, which was the necessary unit for comparative purposes. The general use of the term "point source" was apt to lead to confusion; naturally, if a source which was a point of light could exist it would save an endless amount of trouble. Why the arc was such a successful lamp and would probably continue to be so for projection purposes, was that it gave a circular source of even intensity, with the result that when projected you get a uniform result. The term projection of light was misleading; one ought strictly to speak of "the projection of light sources," and then it would be more generally remembered that whatever the shape of that light source this would be reproduced in the beam or on the illuminated area. This was well illustrated in a lamp which was mentioned in the paper produced by Mr. Aldis; this was a daylight signalling lamp, in which was used an 8-volt or a 6-volt gasfilled lamp with two filaments

side by side—that signalling lamp simply projected those filaments nearly as clearly as a magic lantern would project a lantern slide.

One way of getting over the difficulty of the increased area of light sources was to have a larger condenser; but as larger lenses meant increased thickness of glass and more absorption loss, the best thing was to have larger mirrors.

This principle is embodied in a new cinema-projector, invented by the speaker, the efficiency of which had proved so much higher than the present types that it was possible to illuminate the screen to the same intensity when using one quarter of the electrical energy at present required for the same purpose. But an equally important feature of this apparatus was the arrangement of the arc crater in such a way as to obtain a source of luminous energy constant in both position and brilliancy.

The Chairman congratulated the authors of the paper and expressed the hope that they would continue their investigations, as this was a branch of illuminating engineering which will have an all-important bearing on the future efficiency of light.

Mr. W. J. JONES, in reply to the discussion, expressed his interest in the display of the colour-projector by Major Klein, and the remarks on the development of special arcs for searchlights during the war by the Chairman.

The chief object in preparing the paper had been to show what results could be obtained in optical lanterns by the use of gasfilled lamps, and how the illumination on the screen compared with that obtained with arc lamps, a matter on which little information has hitherto been available. He had had experience of arc lamps over a number of years and agreed that, if they worked satisfactorily, the nature of the source was well adapted to projection purposes. But the fact that the filament of a gasfilled lamp was situated in a sealed glass envelope, and that such lamps required no manipulation once they were switched on, were obvious advantages, and if such lamps were made in a form suitable for projectors and for use on the higher voltages of 200 volts, or more, they should be very serviceable. He had found that in schools and colleges the simplicity of the gasfilled lamp was particularly suitable. He should explain that the reason why one particular form of arc lamp was used in these experiments was that he had been specially asked to consider the substitution of gasfilled lamps for an arc of this type in an educational institution.

However, while he believed that gasfilled lamps had great possibilities, he agreed that at the present stage of manufacture they could not be used for every purpose, and that at present the brightness of the filament was not sufficient for projection on a very large screen, or in kinema halls where a very great volume of light was required.

He entirely agreed with Mr. Buckell in his advocacy of low voltage lamps; the lower the voltage that could be used the higher the proportion of light that could be transmitted efficiently through the condenser system. The remarks by Dr. Clay and Mr. Dow would serve to show the attention that was being devoted to the design of condenser systems, and there was no doubt that there were considerable opportunities for experiment with a view to finding optical systems best suited to various illuminants. He had been criticised for using the term "horizontal candlepower," but in this case the useful light formed a cone about a horizontal axis, and therefore the value of the "horizontal candlepower" represented this better than does the "mean spherical candlepower."

TESTS OF HIGH INTENSITY ARCS FOR KINEMA WORK.

IN a recent issue of the *General Electric Review* (U.S.A.), Mr. F. A. Benford gave some details of tests of kinema projectors, the light being directed down a tunnel on to a white hemispherical integrator. This enabled the total useful flux from the new types of arcs to be measured. Attention is drawn to the effect of angle between the electrodes and it is shown that near normal rating the light falls off 23 per cent. for a 10 per cent. change in current.

INVESTIGATIONS ON KINEMA PROJECTORS.

SOME interesting investigations of the efficiency of kinema-projectors were described in a paper read by Dr. W. Meinel before a joint meeting of the Illuminating Engineering Society in Germany and the German Kinematograph Society and summarised in a recent issue of *Licht und Lampe*. The efficiency of the apparatus may be defined as $P = \frac{\phi_2}{\phi_1}$ where ϕ_1 is the primary flux of light emitted by the lamp, ϕ_2 the secondary flux of light received by the screen. $\phi_2 = E.F$, where E is the mean illumination on the screen in lux and F the illuminated area in sq. metres, $\phi_1 = J_{\supset}.2\pi$, where $J_{\supset}$ is the mean candlepower within the hemisphere including the projecting system. Hence if we denoted the specific efficiency of the source by $\epsilon = W/HK_{\supset}$ (*i.e.*, watts per hemispherical candlepower), we have the relation :—

$$E = \frac{P.W.\ 2\pi}{F.\ \epsilon}$$

The optical efficiency of the projection system, P, is, with the usual three-sector shutter, only about 1·3 per cent. The author presented a diagram showing the size of screen that could be illuminated with an intensity of 50 lux* with various currents through the arc and different methods. Thus with a d.c. arc and the ordinary condenser a screen 6 metre square could be illuminated to 50 lux with a current of 65 amps.; over a fairly wide range the permissible screen-area is roughly proportional to the current used.

The author next proceeded to discuss the efficiency of the source itself, giving the familiar diagram showing the proportion of the total radiant energy which appears in a luminous form. With the arc used in the ordinary kinema projector this fraction is only about 7 per cent. Therefore, one is justified in saying that of the energy supplied to the arc only "1·3 per cent. of 7 per cent.," *i.e.*, less than 1/10 per cent., is usefully employed.

* Very approx. 5 foot-candles.

Many efforts have been made to improve the luminous efficiency of the illuminant. For example, in the Lummer arc under high pressure an intrinsic brightness as high as 1,200 candles (Hefner) per sq. mm. of crater was attained, but on practical grounds this is not readily applicable to the kinema industry. The most promising line of research is the improvement of the optical system of the projector. By substituting a concave mirror behind the arc for the usual condenser lens the efficiency can be increased four-fold. The author described this new arrangement, pointing out how the mirror enabled a much larger proportion of the flux of light to be directed on to the objective. The method is similar to that used with searchlights, where the crater, on the horizontal positive carbon, faces the mirror, and the negative is made as small as possible. It has been found that with a mirror the horizontal arrangement of the electrodes is preferable to their use at right-angles, as in some projector lamps. The author gave a practical demonstration showing that the screen was better illuminated by an arrangement of this kind using a 6 amp. arc than by a 40 amp. arc with the ordinary condenser lens.

The discussion turned chiefly on the question of the quality of the mirror and its capacity to withstand heat. Dr. Meinel explained that a metal mirror, preferably one with a polished nickel surface, was better than silvered glass. While some speakers contended that the surface of the latter should not be affected by heat, it was suggested that there was risk of cracking or deformation of the glass. On the other hand, Dr. Meinel stated that the nickel metal reflector answered quite well, and did not appreciably discolour, and its practical advantages outweighed the drawback of the somewhat lower reflecting power (about 65 per cent. as compared with 80 per cent. with silvered glass).

THE LIGHTING OF MONUMENTS.

THE question of providing artificial lighting for the Cenotaph in Whitehall has again been raised in the *Times*. This is a good instance of a monument of national importance that ought to be made visible by night as well as by day, and it is to be hoped that the suggestion will receive sympathetic consideration. The method of lighting would require special care in order to produce a dignified and impressive effect, and the guiding principle should be the use of concealed lights so as to avoid any dazzle liable to prove inconvenient to drivers of vehicles in this important thoroughfare. H.M. Office of Works would, it is presumed, refer the matter to the committee of eminent architects and sculptors who advise on national monuments, and it is desirable that advice of experts on illumination should also be sought.

There are many other monuments to which concealed lighting might with advantage be applied. It has been pointed out, for instance, that the Queen Victoria Memorial at the end of the Mall is a striking object by day, forming a fitting termination to the long vista seen through the Admiralty Arch. But at night it is lost in obscurity.

AN "ANTI-DAZZLE" HEADLIGHT FOR BUSES.

AN enterprising step taken by the London General Omnibus Co. has been the adoption of the "National" lens, a new type which is claimed to eliminate glare, for the headlights of motorbuses. It is stated that the lens has been subjected to many tests made in conjunction with the licensing authorities of Scotland Yard, and that besides the diminution of dazzle the illumination on the roadway is very considerably increased as a result of the deflection of light below the eye-level. An opportunity of witnessing the new headlights in operation was recently provided for the Press, and it appears that the new device, which is to be used mainly on the Company's rural routes, will prove very useful.

GOOD LIGHTING ESSENTIAL IN THE EXAMINATION OF FURNITURE.

AN instance of the value of good lighting, in assisting the critical examination of antiques, was afforded in a recent case in which the genuineness of furniture supplied was contested. An expert on antiques expressed the opinion that a Jacobean chair was not genuine, and was reminded that this did not entirely coincide with the opinion he had previously expressed. He replied that he had made further discoveries in the better light of the court, and was asked: "Before you make statements, why don't you take the trouble to examine the things in a good light?"

It is evident that, as a judgment of the genuineness of such articles often depends on the examination of minute details, conditions of illumination are of considerable importance to the expert. Apart from the question of sufficiency of light, the *colour* may be of importance. Possibly an accurate form of artificial daylight would ensure safer decisions that win some cases than when ordinary illuminants are used.

PERSONAL.

WE understand that Dr. E. P. Hyde, who organised the Nela Research Laboratories in 1908, and who for the past few years has occupied the position of Director of Research of the National Lamp Works of the General Electric Co. (U.S.A.), has tendered his resignation to take effect on June 30th of the present year.

Dr. Hyde, who is a Past-President of the Illuminating Engineering Society in the United States, and who has taken an active part in discussions and experiments on illumination for a number of years, has decided to take a prolonged rest abroad. He will temporarily discontinue many of his activities in the scientific and engineering societies, but will retain his office as President of the International Illumination Commission until its next plenary meeting.

THE ILLUMINATION OF POST OFFICES.

In a recent issue of the *Electrical World** a summary is given of a survey of the lighting of post offices carried out at the request of the Office of Industrial Hygiene of the United States Public Health Service.

Various defects were observed in the post offices studied. The report states that the illumination was deficient, lights were incorrectly spaced and glare and numerous shadows were in evidence. In some cases the values of illumination were below those given in American codes and those usually furnished in industry.

It is remarked that there seems to be a definite relation between defects of vision and the amount of illumination prevailing. Thus it was found that in an old post office the majority of workers, who received an average illumination of 2—3 foot-candles, had less than normal vision, and certain defects were more frequent than in a new post office where 3 to 4 foot-candles was provided. Up to a certain point the higher the illumination the more rapidly was the work performed. Those having normal eyesight worked most rapidly under an illumination of 8—10 foot-candles; those with defective eyesight showed less fatigue when working under higher intensities than when with lower illuminations.

"It is recommended that the present system of illumination in the post offices should be changed. There should be installed in the general workrooms and offices systems of totally enclosed units of the diffusing or light-directing type, giving a general intensity when first installed of 10 foot-candles everywhere on a horizontal plane 45 in. above the floor. All local lighting should be done away with."

It is also recommended that the surface brightness of the lighting units should not exceed 2·5 candlepower per sq. in. when used with a lamp emitting 3,100 lumens, that the unit should have an output of at least 80 per cent. of that of the clear lamp, and that the certain proportions of the total flux of light should be emitted in specified zones. There is a further requirement, with a view to avoiding glare, that the brightness of the units, measured in lumens per square foot, must not be more than 100 times as great as the intensity of the illumination, measured in foot-candles on the working area. In order to obtain the recommended intensity of 10 foot-candles on the working plane it would be necessary to use about 2 watts per square foot of floor area in the general workrooms of the post office. Reference is also made to the need for careful location of light sources used to illuminate vertical surfaces, such as separation cases.

As regards maintenance it is recommended that "Care of the lighting should be placed in the hands of one man who should be responsible for the upkeep and care of the units. He should make a daily round of the building and replace all burnt-out lamps and broken fixtures. He should cause the lighting units to be cleaned once a week, or as often as is necessary to keep them clean. He should see that the walls and ceilings are kept in good condition so as to serve as good reflecting surfaces for the light. He should make measurements once a month with a foot-candle meter, in order to see that the uniformity and constancy of the illumination are maintained."

In connection with the process of sorting it is pointed out that there are many different colours and combinations of colours among the mail matter, although black ink on a light or white surface predominates. There are many combinations, however, which are distinctly trying to read, handicapping the worker and straining his eyes. Such combinations are a dark background with an ink of the same colour, but slightly lighter shade, and colours which give little contrast. To read all the addresses on the foreign mail and to distinguish the marking on foreign stamps a particularly good light is required. Frequently glossy envelopes or, in recent years, "window envelopes," are used, which render the reading of addresses less easy.

It is pointed out that during recent years there has been a steady increase in the degree of illumination recommended as necessary in different textbooks and codes. Such a marked increase in speed

* March 24th, 1923.

and accuracy in the work of the post office was found when the illumination was raised to 8 foot-candles that it was deemed desirable to calculate the decrease in the cost of labour and the increase in the cost of lighting, and compare the two. The increase in the cost of the higher illumination, 10 in place of 3·6 foot-candles, was about $39,500. The total pay-roll for the office is $6,746,039 per annum. As the workers spend only about half their time under artificial illumination, about half this amount, approximately $3,400,000, will represent the amount paid for work done under artificial light. In speed and accuracy tests it was found that for the letter separators there was an average increase in speed of at least 4·4 per cent. Since all the work of the post office makes similar demands on the eyes, it may be assumed that this increase in speed is general. The pecuniary gain is therefore 4·4 per cent. of $3,400,000, *i.e.*, about $148,000, whereas the cost of the increased lighting was only $39,500. Thus the net saving for this post office would be *twice* the increased cost of illumination.

AN EXCHANGE OF PROFESSORS BETWEEN FRANCE AND THE UNITED STATES.

THE system whereby professor universities in different countries exchange professors for a short period has much to recommend it. We notice Dr. A. E. Kenelly, of Harvard University, a Past-President of the American Illuminating Engineering Society, recently returned from a year's absence in France, where he exchanged duties with Prof. Jacques Cavalier, of the University of Toulouse, and delivered 84 lectures on power transmission and other matters. Dr. Kenelly, whose views are quoted in the *Electrical World*, was impressed by the thoroughness of French higher education. The graduate in science is a highly trained specialist, but has had little contact with industry and practice. This comes later. Dr. Kenelly advocated the exchange of graduate students for a year's residence, as an aid to the interchange of ideas and as being of benefit to the educational world in both countries.

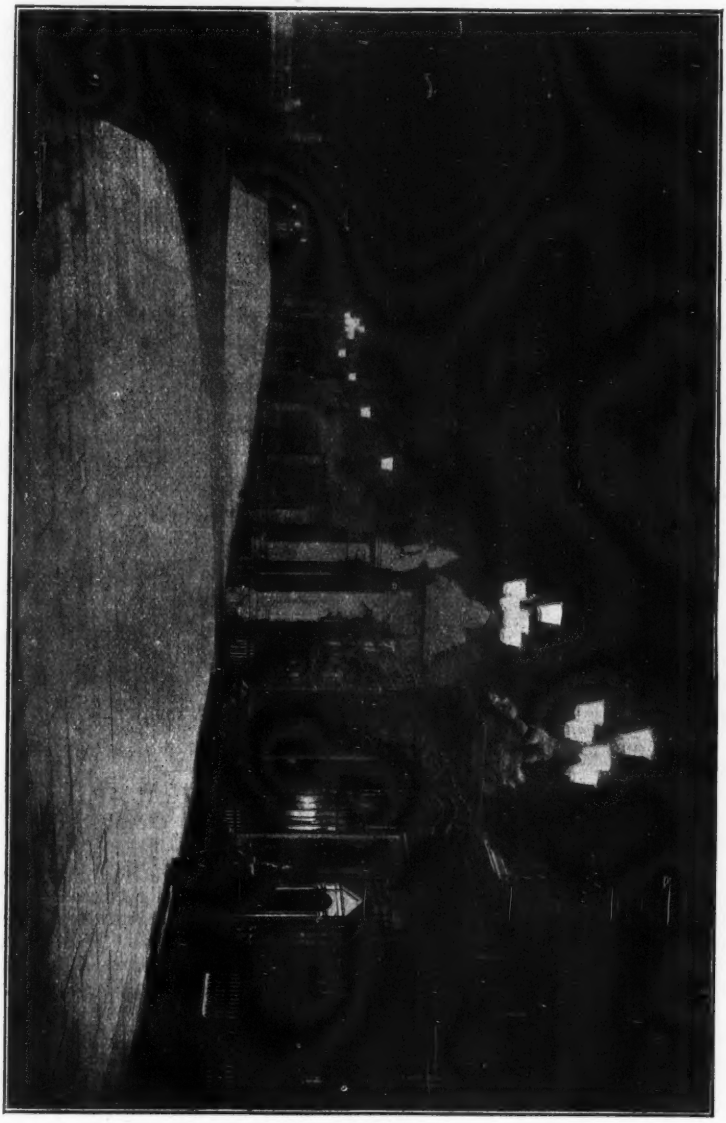
BRITISH INDUSTRIAL "SAFETY FIRST" ASSOCIATION.

AT the Annual Meeting of the British Industrial "Safety First" Association, held at Caxton Hall on February 16th, encouraging evidence of progress was presented. In the Annual Report it was recalled that industrial accidents during 1921 numbered 285,746 and involved compensation payments amounting to £5,509,395. The remark of Mr. Gerald Bellhouse, C.B.E., H.M. Chief Inspector of Factories, that 75 per cent. of industrial accidents are preventable, was also quoted. Experience of firms who are members of the Association has shown that the application of safety first principles during periods of only 1 to 3½ years has led to decreases in accidents ranging from 21 to 76 per cent. Further confirmatory evidence of the value of the movement was given by various speakers.

At the subsequent Annual Dinner Lord Armstrong, the President for 1923, presided. The toast of the Association was proposed by Sir William Joynson-Hicks, who pointed out that the universal application of safety first methods should save at least 2½ million pounds per annum in compensation, and save 140,000 homes from the trouble and anxiety arising from industrial accidents. An important step announced by Mr. H. E. Blain, C.B.E., was the formation of a new National "Safety First" Association, which will link up the work being undertaken by the B.I.S.F.A., the London "Safety First" Council, and other organisations throughout the country.

THE COMMERCIAL MOTOR TRANSPORT AND ROADS DEVELOPMENT EXHIBITION.

WE are informed that the Society of Motor Manufacturers and Traders, Ltd., have decided to organise an Exhibition embracing the various types of commercial motor vehicles, components and accessories, and also plant, machinery and material used in the construction, maintenance and development of roads. The exhibition will be held at Olympia during November 22nd to December 1st, 1923. All particulars can be obtained on application to the Society's offices, 83, Pall Mall, London, S.W.1.



Gas Lighting outside Buckingham Palace.

Above is a pleasing view, taken by artificial light, of the exterior lighting by low pressure gas lamps outside Buckingham Palace, which was modernised a few years ago when the face of the Palace was remodelled.

FIG. 1.

Night Photograph of one of the signals at Victoria Station. The signals are controlled electrically, but are lighted from behind with high pressure gas.

RAILWAY SIGNAL LIGHTING WITH GAS.

AMONG the many applications of light on railways none is more important than the lighting of signals so that they can be clearly seen at night. The two accompanying illustrations, for which we are indebted to the British Commercial Gas Association, show the use of high pressure gas lamps for this purpose at Victoria Station. The lamps are supplied from the high pressure services through double governors, an arrangement which avoided the expense of running special low pressure mains. Fig. 1 is a front view, Fig. 2 a view from behind showing the position of the lamp. It will be noted that the actual source is concealed from view; the driver of an approaching train sees only the brightly illuminated signal which consists of translucent glass. It is interesting to note that while the lighting is effected by gas the signals are electrically controlled.

It may be recalled that Victoria Station is now lighted by high pressure gas (54″), and it is stated that 431 lamps, with a total of 125,000 candlepower are used; 300 and 500 candlepower units are used on the platforms, and are mounted 50 feet apart and 12 feet above platform level. Another interesting feature of the lighting arrangements is the use of special distance control, whereby alternate lamps can be lighted or extinguished in series from the control point—a method which is conducive to economy, as the consumption of any part of the station can be reduced by half when not actually required for traffic.

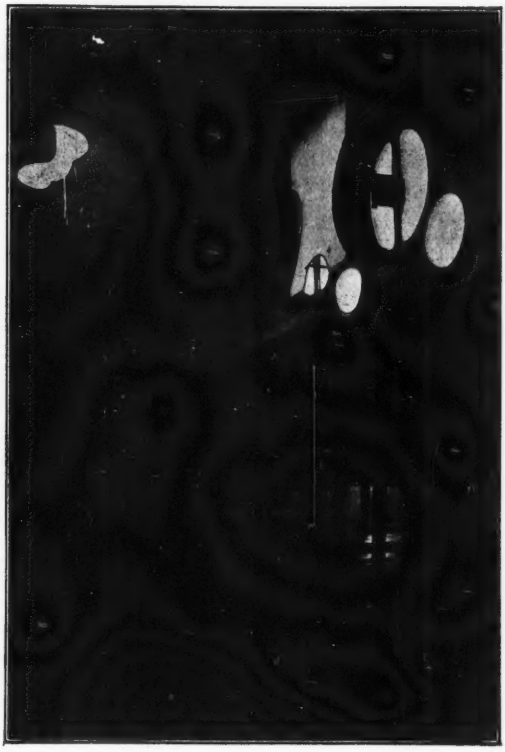


FIG. 2.

A Night Photograph taken behind the signals, showing one of the high pressure gas lamps with special reflector to concentrate light on the signal.

THE FORTHCOMING NATIONAL GAS EXHIBITION.

The attention of readers is drawn to the forthcoming National Gas Exhibition, to be held in the Bingley Hall, Birmingham, during September 17th to October 3rd, 1923, under the Presidency of the Rt. Hon. the Lord Mayor of Birmingham (Alderman David Davis, J.P.). The Presidents of the various national bodies concerned with gas, and also the President of the Illuminating Engineering Society, are included in the list of Vice-Presidents, and the Exhibition is receiving influential support.

It is interesting to note that this is the first National Exhibition in this country since that held in London ten years ago. The moment is therefore timely to review recent developments, and the Exhibition will doubtless furnish useful opportunities of emphasising the benefits of good illumination.

There will be representative exhibits illustrating domestic and industrial applications of gas, and a series of popular lectures. It is also proposed to arrange a special section containing objects of historic interest

GAS ENGINEERS AT BELFAST.

The Annual Meeting of the Institution of Gas Engineers will take place from the 26th to the 28th June at Belfast, under the Presidency of Mr. James D. Smith, M.Inst.C.E., Chief Engineer of the Belfast Corporation Gas Works. The Institution will be welcomed by the Lord Mayor of Belfast (Alderman W. G. Turner) who will, with the Lady Mayoress, hold a reception in the City Hall on the evening of the 26th. The Presidential Address will be delivered on the morning of that day, and a presentation of the Birmingham Medal will be made to Mr. W. Doig Gibb, M.Inst.C.E., O.B.E., Consulting Engineer of London, formerly Chief Engineer, Newcastle and Gateshead Gas Company, and afterwards Chief Engineer, South Metropolitan Gas Company, and a Past President of the Institution of Gas Engineers. The mornings of the 27th and 28th will be devoted to papers on various gas engineering subjects, and in the afternoon of the 27th members will be entertained to luncheon by Councillor Frank Workman, Chairman of the Corporation Gas Committee, after which the gas works will be open for inspection.

THE STANDARD U.S.A. SPECIFICATION FOR ELECTRIC INCANDESCENT LAMPS.

A CIRCULAR (No. 13) issued by the Bureau of Standards contains particulars of the new standard specification for large tungsten filament incandescent electric lamps officially adopted last year. In the introduction attention is drawn to the recent abandonment of the long-established provision that the life of test lamps should be considered as ended when the candlepower had fallen to 80 per cent. of the initial value.

This was suitable for carbon lamps, but tungsten lamps, in which excessive blackening of bulbs can be prevented, normally burn out before their efficiency has fallen low enough to justify replacement. Hence the new tests are based on the total life to the time of burn out. But the performance of lamps throughout their life is taken into account by two provisions—the evaluation of life-test results on the basis of average efficiency throughout life instead of initial efficiency, and the requirement that the average light-flux during the life of the lamp must not fall below a specified percentage of the initial flux.

There is also a clause permitting the manufacturer to reduce the efficiency rating of any size of lamps by as much as 4 per cent., on notice to the buyer. The lamp schedules recognise officially only 5 volt steps in the 110-120 volt range and 10 volt steps in the 220-250 volt range.

The directions for life-performance and inspection tests follow similar lines to those adopted in previous specifications. Quantities for initial rating test must not be less than 5 per cent. of the lamps inspected, and if more than 3 per cent. of lamps are vitally defective the lot may be rejected. Rejection is also permitted if more than 20 per cent. of lamps fall outside the initial rating tolerances (5 per cent. for lots of 250 and over).

For vacuum tungsten filament lamps on 110-120 volt circuits the initial lumens per watt range from 8·9 for the 10-watt size to 11·6 for 60-watt lamps; with gasfilled lamps for the same voltage from 13·2 for 60 watts to 22·6 for the 1,000-watt type. Particulars of bulb-dimensions are also given.

The above data deserve study in view of the fact that the subject is now receiving attention in this country.

DATA ON LAMPS IN GERMANY.

IT is also of interest to observe some figures for the performances of lamps in Germany, as specified in makers' lists, given in an article by J. Schaer in *Licht und Lampe*. For 100-130 volts, lamps taking from 25 to 2,000 watts are listed. The smallest lamp yields 9 lumens per watt, the 100-watt type 13·8 lumens per watt, and the 2,000-watt lamp 21·2 lumens per watt. For 200-260 volt efficiencies are somewhat lower. Thus the 40-watt lamp (the smallest listed) yields 8·4 lumens per watt and the 2,000-watt type approximately 20.

It is pointed out that in large interiors consumers gain by using the higher candlepowers. For instance, to take an extreme case, assuming the higher range of voltages, ten 150-watt lamps would give about 20,000 lumens, whereas a single 1,500-watt lamp would yield 29,000 lumens—an increase of approximately 45 per cent.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

FLOODLIGHTING OF A WAR MEMORIAL.

Attention has often been drawn to the possibilities of floodlighting effects for the illumination at night of monuments, war memorials, etc. The accompanying illustration, furnished by the General Electric Co., Ltd., shows the lighting by this method of the Brighton War Memorial by G.E.C. floodlights fitted with Osram gasfilled projector type lamps. The lamps are completely concealed from view and the memorial stands out strikingly in the darkness.

SWITCHGEAR AND CUT-OUTS.

Two leaflets, issued by the General Electric Co., Ltd., Nos. 205 and 226, give particulars of "Salford" Ironclad Switchgear and "Bobbin" Cut-outs. Attention is drawn to the good breaking capacity of these switches, which, it is claimed, will safely break 1½ times their nominal rating, the blades being insulated from each other and from earthed metal by means of Bakelite tubes.

LAMP CONTRACTS.

We are informed by Messrs. Siemens and English Electric Lamp Co., Ltd., that the London County Council have renewed their contract for the supply of the whole of their requirements in electric incandescent lamps, including gasfilled, vacuum type and carbon filament lamps, for a further period of twelve months; also that the company has secured a contract from the Port of London Authority for the supply of Siemens gasfilled type lamps.

"INTERNALITE" SIGNS.

A booklet issued by the K.F.M. Engineering Co., Ltd. (4, Long Acre, London, W.C.2), contains some pleasing illustrations of "Internalite" signs, showing their use for notices, garages, etc., as well as for specialised advertisements. It will be recalled that the distinctive feature of this sign is that the lettering is engraved on the back of a sheet of plate glass, illuminated by tubular lamps concealed along the edges, so that the lettering stands out brightly illuminated with a transparent background. Striking colour-effects can be obtained with these signs, and a colour plate illustrating the "rainbow" effect forms the frontispiece of the booklet.

B.T.H. INCANDESCENT ELECTRIC HANDBOOK.

A new and revised edition of the B.T.H. Incandescent Electric Handbook (1-D) is now available. As in former editions the booklet commences with diagrams showing the chief parts of the lamp, definitions of the chief terms used in illuminating engineering, tables of co-efficients of utilisation, etc. The usual lists of lamps, with voltage, consumption and dimensions indicated, follow, but new data are included on Daylight Lamps (intended to furnish "artificial daylight"), Neon Lamps and "White Mazda" lamps with special diffusing bulbs. At the end there is a short summary of the qualities of tungsten, and its application to lamps in the form of drawn wire. There are also schedules of carbon lamps and dimensions of standard screw and bayonet caps.

WIRELESS DEVELOPMENTS.

The "Aristophone" catalogue issued by Messrs. C. E. Elwell, Ltd., contains a varied and up-to-date assortment of wireless receivers including cabinets de luxe and down to small parts. But the firm is also associated with the transmitting side of wireless work and, among other matters, has made a speciality of aerial structures. The Elwell towers are of four distinct types and may utilise either lattice woodwork or steel. Those of lattice woodwork are particularly interesting, and besides being resilient appear to be much more robust than the layman might suppose; an illustration shows a 446 tower of this type at Horsea Island sustaining the impact of collision with a heavy seaplane. It is stated that creosoted wooden stayed towers will last 35-50 years, self-supporting steel towers 80-100 years, and concrete towers probably longer still.

Another booklet deals with the Elwell Arc Equipment, contains details of some of the larger wireless stations, and describes the continuous wave arc system of transmission. High frequency arc equipments, as installed at the East London College and the City and Guilds Engineering College, are proving very useful for various forms of electrical research work, and the Elwell "Book of Diagrams" should in these days of broadcasting also be of interest to amateurs in wireless.

PUBLICITY NOTES.

Annual Tables of Constants and Numerical Data.

These very comprehensive tables are published under the patronage of the Conseil International de Recherches and the Union Internationale de la Chimie. The price of copies is 11s. in paper cover and 13s. in cardboard cover, and copies can be obtained on application to the Secretary of the Committee, M. Charles Marie, 9, rue de Bagneux, Paris.

We learn that the *Architectural Students' Handbook*, which was reviewed in this journal last year, has now reached its second edition, and the price has been reduced to 7s. 6d. per copy.

We understand that Messrs. Ernest Benn have just published an enlarged and revised new edition of Mr. Stanley Cooper's work on *By-Product Coking*. The same firm are also publishing a textbook on *Gas Producers*, by Mr. N. E. Rambush, in which special attention is devoted to the recovery of ammonia and low temperature tar-oils.

INDEX, March, 1923.

	PAGE
British Industrial Safety First Association, Annual Meeting	76
Editorial. By L. GASTER	57
Furniture, Use of Light for the examination of	74
Illuminating Engineering Society— (Founded in London, 1909)	
Account of Meeting on February 20th	61
New Members	61
The Projection of Light. By W. J. JONES and E. A. MARX, Junr. ..	62
Discussion—Major A. KLEIN—J. ECK—Comm. T. Y. BAKER—R. S. CLAY—T. E. RITCHIE—L. E. BUCKELL—P. J. WALDRAM—W. E. TRUSLER—J. S. DOW—HAYDN T. HARRISON (Chairman)—W. J. JONES (in reply)	72
Kinema Projectors, Researches on	73
Monuments, Lighting of	74
Post Offices, Lighting of	75
Railway Signal Lighting with Gas	78
REVIEWS OF BOOKS	83
Standard Specification for Electric Lamps (U.S.A.)	80
TOPICAL AND INDUSTRIAL SECTION	81

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Elementary Principles of Lighting and Photometry. By John W. T. Walsh. (*Methuen and Co., Ltd., London*, 1923. *pp.* 220. 85 *diagrams.* 10*s.* 6*d. net.*)

MR. WALSH'S book is an important contribution to literature on illuminating engineering. Sir Joseph Petavel, in an introductory note, comments on the growth of interest in the subject during recent years, mentioning, as an illustration of the need for scientific methods, that national expenditure on artificial lighting runs into hundreds of millions per annum.

The book proceeds in logical sequence, the initial chapter being devoted to light, vision and the eye. We then pass on to the measurement of candlepower and illumination, and a brief discussion of modern sources of light. The second half of the book is devoted to chapters dealing with industrial and school lighting, outdoor illumination, daylight, colour-effects and the projection of light. The only respect in which the arrangement of the matter might be altered is the inclusion of the discussion of heterochromatic photometry and flicker photometers in the last chapter but one, dealing with colour. In a subsequent edition this might with advantage be transferred to the early chapters dealing with photometry.

The account of the eye and theories of vision, leading to a discussion of glare, is lucid and useful, and there is a brief reference to effects of ultra-violet light. In the subsequent chapters on photometry Mr. Walsh is in his element, and the account of laboratory methods, doubtless based largely on methods adopted at the N.P.L., should be a useful guide to those who have to undertake work of this kind. The treatment of the use of the integrating sphere, in particular, contains what is needed without being too elaborate. In the chapter on illumination photometers, illustrations of most types of instruments are included, and service-

able hints on their use in practice are given. It is interesting to note the author's remark that, when all necessary precautions are taken, an accuracy of 2—3 per cent. can be obtained with the best of such instruments; but it is probable that the ordinary user would not expect an accuracy exceeding 10—15 per cent. in practical work.

In the chapter on Modern Light Sources Mr. Walsh adopts the judicious method of giving results in terms of average (mean spherical) candlepower. The account of methods of testing electric lamps, including life-tests, is detailed, but a little more information on methods of dealing with flame sources would be welcome, and it is possible that some of the values given for such sources would not meet with general acceptance.

The subsequent chapters dealing with practical lighting problems cover a wide field, and the matter is well selected. The author has evidently made good use of information presented at meetings of the Illuminating Engineering Society during recent years. Such problems as the lighting of shops, churches, theatres and kinemas, museums and art galleries are briefly dealt with. Mr. Walsh's experience, both at the N.P.L. and in connection with the Home Office Departmental Committee on Lighting in Factories and Workshops, enable him to deal with industrial lighting in a very comprehensive manner. Lighting in mines is also briefly dealt with in this chapter; in a future edition some reference to the important relation between inadequate lighting and the prevalence of miners' nystagmus should be made. The inclusion of a chapter on daylight illumination is a useful feature; this, again, is a subject of which the author has gained special experience at the N.P.L. The two final chapters contain much interesting information on miscellaneous problems, such as artificial daylight, floodlighting and motor-headlights.

Finally, there is a suitable index and bibliography, in which references are arranged according to subjects treated. The author explains his reasons for including references in an appendix at the end of the book, and there is much to be said for the course; however, in a few cases, where matters of principle are involved, additional references amidst the text might usefully be included. It is only necessary to add that the paper and type are good, and that the well-executed diagrams by Mr. F. G. H. Lewis are of great assistance to the author's lucid treatment of the subject.

The Practical Electrician's Pocket Book. (*S. Rentell and Co., Ltd., London.* 1923. *pp.* 571+xci. 3*s. net.*)

THE twenty-fifth annual issue of *The Practical Electrician's Pocket Book* makes a welcome appearance. It now contains nearly 600 pages of closely printed matter, at the very reasonable price of 3s., and has, as usual, been revised and brought up to date. The contents of the pocket book must by now be familiar to our readers, but we note that many sections, including those on steam boilers, control gear for d.c. and a.c. motors, portable electric tools, etc., have been rewritten, and an entirely new chapter of Wireless Broadcasting has been added. Additions have also been made to other chapters. As in former editions, there is a useful section on lighting, which has been kept up to date. In the next edition some reference to the reports of the Home Office Departmental Committee on Lighting in Factories and Workshops might, however, be included.

The Spectroscope. By T. Thorne Baker (*Balliere Tindall and Cox, London.* 1923. *pp.* 208+x. *Figs.* 94. 7*s.* 6*d. net.*)

THIS book is intended to bridge the gap between ordinary treatises on general physics and modern advanced works on the spectroscope. The first chapter deals with elementary ideas on colour, wavelength, etc.; Chapter II. with the prism spectroscope and plane and concave gratings. In Chapters III. and IV. the adjustments of the instrument are described, and some account given of its uses for determining refractive indeces, and as an aid to chemical analysis. Methods of producing spark, arc and vacuum tube spectra are explained. Next there is a section of special interest to our readers, namely, that dealing with illuminants and the distribution of energy in the spectrum, fluorescence and phosphorescence, etc. There is also some reference to photo-electric effects and the mapping out of the infra-red spectrum. Spectro-photography and the preparation of photographic plates for such work next claim attention, after which there is a brief account of spectro-photometers. Finally, there is some account of the new field of X-ray spectra.

While the book is intended to be fairly elementary in scope, and some aspects, such as the astronomical side of the subject, are not touched upon, it contains much useful and up-to-date information, and should serve as a useful introduction to more advanced and specialised treatises

Book.
1923.

f The
makes
ntains
rinted
ice of
d and
of the
iar to
many
oilers,
otors,
been
ter of
dded.
other
here is
h has
next
rts of
mittee
kshops

Baker
ondon,
7s. 6d.

e gap
eneral
ks on
deals
wave-
prism
ncave
V. the
e des-
s uses
, and
thods
cuum
there
o our
with
nergy
phos-
some
d the
trum.
ration
next
brief
nally,
eld of

fairly
pects,
f the
ntains
ation,
action
atises